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# Status and public perception of the 'New Zealand flatworm', *Artioposthia triangulata* (Dendy), in Northern Ireland

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**Summary.** Since the terrestrial flatworm, *Artioposthia triangulata* (Dendy), was first recorded in Northern Ireland in 1963, sightings from the general public have been collected by the Department of Agriculture for Northern Ireland. By the end of 1997, the cumulative total had reached 1019. Prior to 1989, the number of reports averaged 3.5 per year but this increased substantially in 1990 following intense media interest in the flatworm. Sightings peaked at over 300 in 1995. *A. triangulata* was found in every major town in the province and the number of reports correlated positively with human population density. Adult *A. triangulata* were found throughout the year but especially in spring and early summer with most sightings from gardens (79.5 %), grassland (6.6 %) and vegetable plots (6.0 %). Of the reports which refer to the impact of *A. triangulata* on earthworm populations, 22.2 % stated that earthworms were absent, 42.4 % stated low and 35.4 % felt that the earthworm population was unaffected. The validity of using information from the public to assess the spread and impact of *A. triangulata* is discussed.

**Key words:** *Artioposthia triangulata,* New Zealand flatworm, planarian, Northern Ireland, distribution, earthworms

## Introduction

The terrestrial flatworm *Artioposthia triangulata* (Dendy, 1895) (Tricladida: Terricola) was first recorded in 1894 (Dendy 1895a) when it was reported to be widespread in the Christchurch area, New Zealand (Dendy, 1895b). In June 1963, *A. triangulata* was discovered outside of New Zealand for the first time, in two gardens on the outskirts of Belfast, Northern Ireland (Anon. 1963; Anon. 1964). By 1977, there were over 30 additional records of *A. triangulata* in Northern Ireland (Willis & Edwards 1977). In addition, international distribution of the flatworm increased to include the Republic of Ireland (Anderson 1986; Hogan & Dunne 1996), Scotland, England (Willis & Edwards 1977; Boag et al. 1994a, b; Boag & Yeates 1995; Jones & Boag 1996), the Isle of Man (Blackshaw & Stewart 1992), and the Faroe Islands (Bloch 1992).

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The 'New Zealand flatworm', *A. triangulata*, is a large and distinctive flatworm which, in a fully elongated adult, can reach over 200 mm in length (Fyfe 1937). The dorsal surface is dark purple-brown with a pale lateral fringe and the ventral surface is pale yellow and peppered with minute grey specks (Dendy 1895b). It is usually found under stones or suchlike shelters on the soil surface, curled in a flat spiral on a bed of mucus (Willis & Edwards 1977). Due to its comparatively large size *A. triangulata* is unlikely to be confused with the two indigenous terrestrial flatworms in Northern Ireland, *Microplana scharffi* (von Graff) and *Microplana terrestris* (Müller) (Anderson 1986), although it may be confused, particularly in the juvenile stage, with *Australoplana sanguinea alba* (*sensu* Jones, 1981), another invading species. *A. triangulata* is hermaphrodite (Fyfe 1937) but it is unknown whether reproduction is sexual or asexual. They deposit ovoid-shaped, shiny-black egg capsules, 3.8–11.3 mm long and 2.6–8.1 mm wide, on the soil surface under shelters. Each egg capsule may contain up to 14 juvenile flatworms (Christensen & Mather 1997).

*A. triangulata* has come to prominence, not only because it is a large and unusual invader but because it is apparently an obligate predator of lumbricid earthworms. Depletion of earthworm populations may affect soil fertility, soil structure (Clements et al. 1991; Haria 1995) and hence agricultural productivity. In addition, earthworms are a major food source for many birds and mammals whose populations would also suffer if earthworm numbers declined (Blackshaw & Stewart 1992).

Since *A. triangulata* was first found in Northern Ireland, reports from the public have been collated by the Department of Agriculture for Northern Ireland into a unique record of the distribution and spread of this invasive pest, its impact on earthworms and how the public perceives it. This paper is the first analysis of these data.

## Materials and Methods

The collection and maintenance of information on *A. triangulata* in Northern Ireland has developed considerably in the past 35 years since the species was first found. Prior to 1989, there was no systematic recording of *A. triangulata*, although all sightings from the public were noted. However interest in *A. triangulata* intensified, after research in the late 1980's demonstrated they could have a detrimental impact on earthworm populations (Blackshaw 1989, 1990). Media attention at this time was stimulated by a project on *A. triangulata* winning the Aer Lingus Young Scientist Competition 1989, which was reported in the press in both Ireland and New Zealand. A spate of media articles on *A. triangulata* followed, often with sensational headlines (Table 1).

Since 1989, reports of *A. triangulata* have been processed via a structured questionnaire. The majority of records were telephoned in following articles in the press and television. All potential sightings were verified by requesting a description of the suspect organism. Observers were then asked for the following information: a) a contact address and telephone number; b) the location where the flatworm was found (eg. garden, arable land, grassland, etc.); c) the status of the earthworm population (absent, low, normal or not noted); d) the original date of discovery; e) whether egg capsules were present. Additio-

**Table 1.** Examples of sensational headlines concerning the 'New Zealand flatworm', *A. triangulata*, from the local and national press in Northern Ireland, 1989–1995

| Headline | Newspaper | Date |
|---|---|---|
| Spare a thought for the humble worm | Belfast Telegraph | 31 Aug 89 |
| Killer worms threaten Ulster farms | Daily Telegraph | 07 Jul 89 |
| Scourge of the killer worms | Daily Star | 08 Sep 89 |
| Worm war | Daily Mirror | 18 Jan 90 |
| MP unearths horror of All Black worm | The Times | 06 Apr 90 |
| Unearthing a slippery customer | Irish Times | 19 Aug 91 |
| Alien flatworms turn the native stock into soup | The Independent | 20 Jan 92 |
| Revenge of the killer worms | The Independent | 12 Jan 95 |
| Kill the Kiwi | Daily Mail | 12 Jan 95 |

nal comments on possible sources of *A. triangulata* and spread to surrounding properties were also noted. Postal submissions of suspect flatworms were occasionally received but were of limited value since the material often decomposed in transit. Sites were visited only when there was an unusual or heavy infestation of *A. triangulata*.

Records were entered into a PC-mounted database (dBASE IV, Ashton-Tate) and spreadsheet (Excel ver. 5.0, Microsoft). Distribution maps were produced using DMAP for Windows (Dr Alan Morton, Blackthorn Cottage, Chawridge Lane, Winkfield, Windsor, Berkshire, SL4 4QR, UK). Human population density was derived from the 1991 population census ( Census Office, Department of Finance and Personnel, Bloomsfield Avenue, Belfast, Northern Ireland).

## Results

At the end of 1997, the *A. triangulata* database contained 1019 records from throughout Northern Ireland (Fig. 1). Most sightings were reported from Belfast, although other towns in the east (e.g. Londonderry) and north of the province (e.g. Coleraine) also had many records. The number of reports of *A. triangulata* was correlated positively with human population density (Fig. 2). The first two sightings of *A. triangulata* in Northern Ireland were from the outskirts of Belfast in 1963 (Anon 1963). However, the next record, in 1965, was from Portadown, approximately 35 km from Belfast. By 1977, *A. triangulata* had been found in Coleraine (75 km from Belfast) and Newtownstewart (90 km from Belfast) (Fig. 3).

Between 1963 and 1989, the reports of *A. triangulata* averaged 3.5 per year. In 1990, the sightings of *A. triangulata* increased substantially and, although there was a drop in sightings the following year, there was a general upward trend to a peak during 1995 (Fig. 4). In 1996, reported sightings fell. Articles in the popular press on *A. triangulata* also peaked in 1995 and declined in 1996 (Fig. 4).

The majority of *A. triangulata* were reported from domestic gardens, although notable numbers were found in grassland and vegetable plots (Table 2). Some of the more unusual sightings were from toilet bowls, with two records submitted by local health authorities; prior to identification one person was treated for helminth infection. On four occasions, flatworms were found attached to pet's fur; it was confirmed that these records were not parasites passed by the animal. One *A. triangulata* was found in a milking parlour on a cow's hoof. Additional comments were received in 30.0 % ($n$ =1019) of reports with most of these concerned the precise location (eg. "under breeze block") or the number of *A. triangulata* found; 15.4 % of the comments suggested that garden plants, manure or topsoil were the source of the flatworm. One report noted that *A. triangulata* had been found on a manure heap which had subsequently been spread on a grass field.

**Table 2.** Habitats from which members of the public reported *A. triangulata* ($n$ = 1010)

| Habitat | % records |
|---|---|
| Domestic gardens | 79.5 |
| Grassland | 6.6 |
| Vegetable plots | 6.0 |
| Domestic toilets | 2.1 |
| Arable crops | 1.5 |
| Forestry | 1.5 |
| Nurseries | 1.0 |
| Golf courses | 0.8 |
| Others* | 1.0 |

* Others include: localities close to slurry pits or manure heaps, under bales of hay, in a cemetery and in a living room, probably carried in on a domestic pet

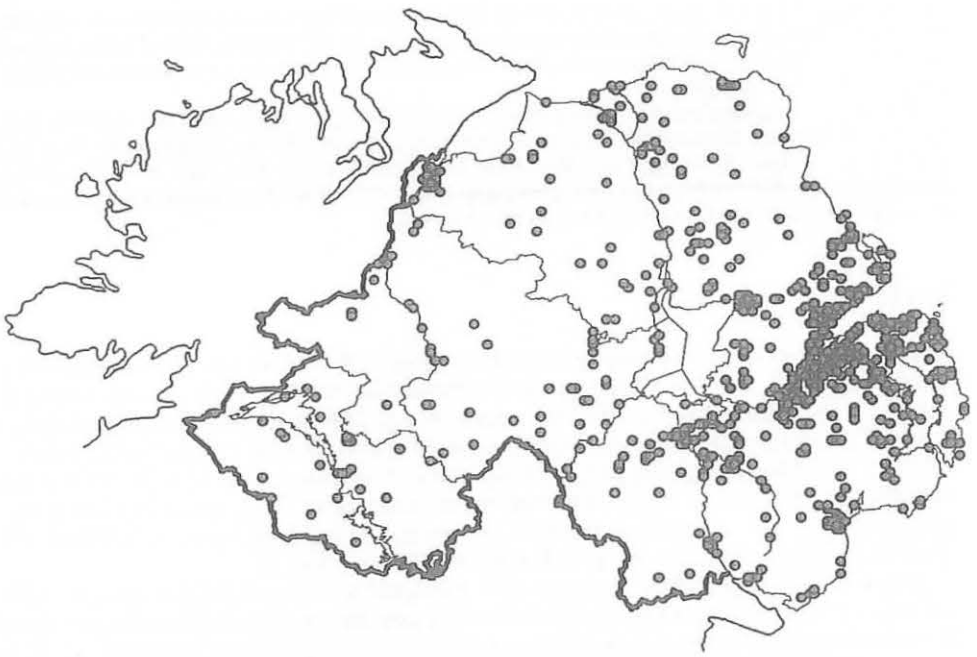

**Fig. 1.** Distribution of individual reports from the general public of *Artioposthia triangulata* in Northern Ireland, 1963–1997

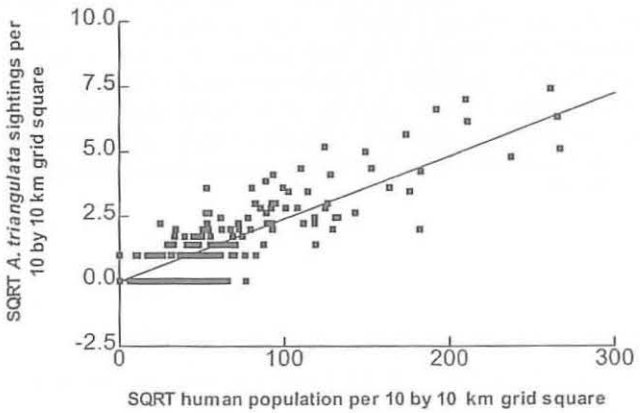


**Fig. 2.** The relationship between the occurrence of *Artioposthia triangulata* and human population density. Both variables were transformed by taking the square root to achieve a normal and homoscedastic distribution of points around the regression line. For reasons of scale, a data point with co-ordinates (513.4, 10.9) representing central Belfast is not shown on the graph. The equation of the regression line is $y = 0.02x - 0.02$; $r^2 = 0.75$, $n = 169$, $P < 0.0001$

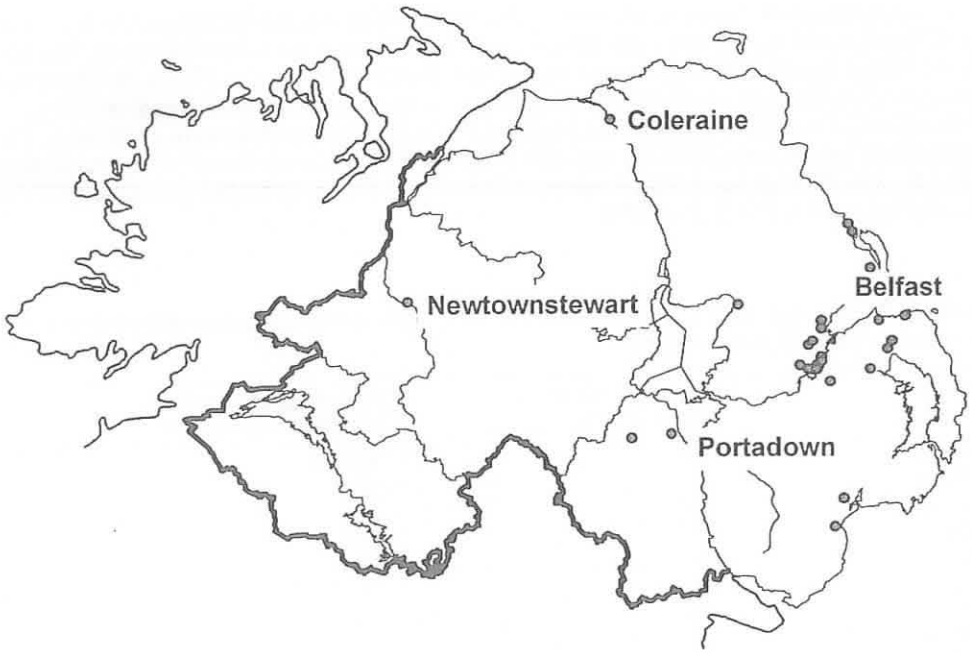


**Fig. 3.** Distribution of reports of *Artioposthia triangulata* in Northern Ireland, 1963–1977 (after Willis & Edwards 1977)

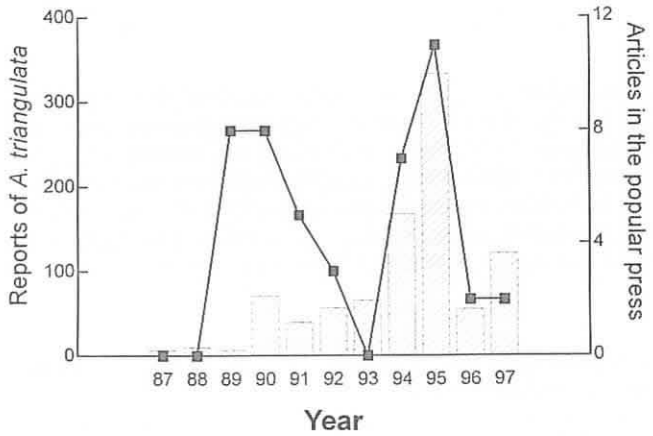


**Fig. 4.** Reported sightings of *Artioposthia triangulata* per year 1987–1997 (bars) and popular press articles in Northern Ireland on the flatworm (line)

*A. triangulata* was found in all months, although sightings varied throughout the year, with most found in the spring and early summer and fewest during the winter (Table 3). The presence of egg capsules was reported in all months apart from December (Table 3). There was no significant difference between the proportions of egg capsules reported each month ($\chi^2 = 3.05$, $df = 8$, $P = 0.93$; where the expected value < 5, adjacent months were combined). The presence of egg capsules did vary between habitat with more being found in vegetable plots (28.8 %; $n = 59$) compared with gardens (14.9 %; $n = 765$) and possibly grassland (17.9 %; $n = 56$) ($\chi^2 = 8.03$, $df = 2$, $P < 0.05$)

**Table 3.** Reports of *A. triangulata* by the public in each month and the percentage of these reports that recorded the presence of egg capsules

| Month | Number of records of *adult A. triangulata* | Percentage of records *reporting egg capsules* |
|---|---|---|
| January | 45 | 13.3 |
| February | 49 | 10.2 |
| March | 92 | 11.9 |
| April | 271 | 14.8 |
| May | 236 | 16.9 |
| June | 116 | 16.4 |
| July | 65 | 16.9 |
| August | 33 | 15.2 |
| September | 20 | 20.0 |
| October | 17 | 23.5 |
| November | 23 | 8.7 |
| December | 7 | 0.0 |

Information on the earthworm populations where *A. triangulata* were found was given in 70.8 % ($n = 1019$) of reports, although this did vary between habitat types with observers from gardens responding in 74.6 % of cases, those in grassland 50.7% and those in vegetable plots 91.8 % ($\chi^2 = 29.03$, $df = 2$, $P < 0.001$). There was no significant difference between habitats in the perceived impact of *A. triangulata* on earthworms ($\chi^2 = 7.04$, $df = 4$, $P = 0.13$) (Table 4), therefore responses were grouped together; overall, 35.4% felt that the earthworm population was normal, 42.4 % stated low and 22.2 % stated that earthworms were absent.

**Table 4.** Perceived impact of the 'New Zealand flatworm', *A. triangulata* on earthworms; reports that did not assess the earthworm population are excluded ($n = 689$)

| | Percentage of responses | | |
|---|---|---|---|
| *Habitat* | *Absent* | *Low* | *Normal* |
| Gardens ($n = 599$) | 22.7 | 42.4 | 34.9 |
| Grassland ($n = 34$) | 14.7 | 35.3 | 50.0 |
| Vegetable plots ($n = 56$) | 25.0 | 51.7 | 23.2 |

## Discussion

Data provided from the public response give a scale of coverage that otherwise would be beyond the resources of investigating bodies. However, interpreting these data requires more care than with a systematic geographical survey by trained researchers due to the increased possibility of erroneous records, fluctuating public response and dependence on anecdotal information. Yet, despite these limitations, public surveys are regarded as a valuable source of information on *A. triangulata* (Alford et al. 1996; Jones & Boag 1996). In a study comparing the effectiveness of information from public and systematic surveys of the spread of a leaf-mining moth, Agassiz et al. (1994) found that information from the public led to an underestimate of the total range but gave a good estimate of where the organism was present at high density.

*A. triangulata* has been reported from every major town in Northern Ireland. Its spread throughout the province is almost certainly facilitated by man's activities, as has been postulated by other researchers (Blackshaw & Stewart 1992; Stewart & Blackshaw 1993; Christensen & Mather 1995; Mather & Christensen 1995). The most likely source of a new infestation is garden plants, although several records suggest that bought-in top soil or manure also carried flatworms. Christensen & Mather (1995) suggested that the spread of *A. triangulata* in the Faroe Isles was facilitated by the need to recycle topsoil and that *A. triangulata* could have invaded a horticultural site via horse manure from local stables. The reports of *A. triangulata*, sticking to pets' fur and to a cow's hoof indicate other means of passive transfer of *A. triangulata*. Of particular note is the comment that an infested manure heap was spread on grassland. This could be a major route of dispersal, especially since manure heaps usually have high numbers of epigeic earthworm species such as *Eisenia fetida* (Savigny), which would be a food supply for the flatworms and could allow their populations to increase. The strong correlation between human population density and number of sightings of *A. triangulata* provides further evidence that the flatworm is largely spread by man. The alternative explanation is that *A. triangulata* is ubiquitous in Northern Ireland and that the sightings merely reflect where people have found them. The latter is unlikely since, in its natural state, the flatworm's only mode of dispersal is by crawling.

The number of reports of *A. triangulata* were comparatively low before 1990, increased substantially in 1990, peaking in 1995 and decreasing in 1996 (Fig. 5). However, although *A. triangulata* has become more prevalent in Northern Ireland in the past 35 years, it seems likely that a major factor in the fluctuation of reports from the public was the amount of publicity devoted to the flatworm by the media. Publicity about *A. triangulata* has two consequences: firstly, it draws people's attention to the flatworm and encourages them to look for it; and secondly, it directs them to contact recording bodies. Separating the influence of publicity about *A. triangulata* from the underlying population growth/spread was not possible with this data set.

Most sightings of *A. triangulata* were from gardens, as expected, given that the most probable mode of dispersal is by infested garden plants. In addition, gardens tend to be the most common way by which public come into contact with soil animals. Grassland and vegetable plots were the next most numerous records. Vegetable plots are mostly associated with gardens and use of infested compost would facilitate transference between these two habitats. The spread of *A. triangulata* into grassland is perhaps of most concern as there is little obvious connection between grassland and gardens, other than active dispersal by the flatworm. Mather & Christensen (1995) found that adult *A. triangulata* were relatively mobile, could move at a rate approaching 17 m $h^{-1}$ and considered local active migration highly plausible. Not only is it likely that grassland infestations are under-reported compared with gardens or vegetable plots, as farmers have less direct contact with the soil, but also there are fewer shelter sites ('refuges') for *A. triangulata* in open grassland. The reports of *A. triangulata* from domestic toilets are too numerous (a total of 21) to be coincidence; it is possible that leaking sewage may provide a food source of earthworms such as *E. fetida* that would attract *A. triangulata* which then entered the toilet via the foul-air vent. Willis & Edwards (1977) repor-

ted an *A. triangulata* emerging from a lavatory bowl in a recently constructed bungalow and suggested that the flatworm entered the sewage system by the inspection cover in the garden. The comparatively few reports of *A. triangulata* from arable crops compared with grassland is not surprising given that 91 % of farmed land in Northern Ireland is under grass and 6 % under crops (Anon 1996).

*A. triangulata* were reported mostly in spring and early summer. It is possible that this was partly a reflection of gardening activity but the pattern agrees strongly with the field trapping results of Blackshaw (1997). However, there was no evidence of seasonal production of egg capsules which contrasts with other studies where peak production occurred in early summer (Blackshaw & Stewart 1992; Blackshaw 1997). A possible explanation for this, is that empty egg capsules do not degrade in the soil and were still reported after they had hatched.

Hancock (1988) and Blackshaw (1989) were the first to report the damaging consequences of *A. triangulata* on earthworm populations. Extrapolating from laboratory-based experiments it was suggested that an *A. triangulata* population of 6.5 $m^{-2}$ could remove an earthworm population in one year (Blackshaw 1991). A further field study reported that complete removal of earthworm fauna did not occur but that the species composition was significantly altered, with surface-active or shallow-dwelling species, such as *Lumbricus terrestris* L., *Allolobophora chlorotica* (Savigny) and *Aporrectodea caliginosa* (Savigny) disappearing and the deeper-dwelling species, *Octolasion cyaneum* (Savigny), becoming predominant (Blackshaw 1995). Although this present survey is based on the public's perception and not physical or chemical extraction of earthworms as recommended for assessment (Sims & Gerard 1985), the many reports of low or absent earthworm populations (64.7 % of positive responses) suggest that *A. triangulata* is depleting the earthworm fauna in Northern Ireland. However, it is probable that many records of absence of earthworms are based on the disappearance of the more noticeable species and that deeper-dwellers, such as *O. cyaneum*, may remain. The difference between responses from the different habitats indicates that those observers from vegetable plots are more likely to notice changes in earthworm populations, probably because they are more frequently turning the soil by hand compared to gardeners or farmers. This, and the refuges provide by pieces of wood etc., are also the most plausible reasons why proportionally more egg capsules were found in vegetable plots compared with gardens or grassland.

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